OIL PALM FROND (OPF) AS AN ALTERNATIVE SOURCE OF PULP & PAPER PRODUCTION MATERIAL

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DECLARATION

I declare that this thesis entitled **"OIL PALM FROND (OPF) AS AN ALTERNATIVE SOURCE OF PULP & PAPER PRODUCTION MATERIAL"** is the result of my own research except as cited in references. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree."

Signature	:……………………………………….
Name of Candidate	: Mohammad Izzuddin bin Yakari
Date	: May 16th, 2006

DEDICATION

Special Dedication to my beloved mother (Azizah) and father (Yakari), for their love and encouragement.

And,

Special Thanks to my friends, my fellow course mate and all faculty members.
For all your Care, Support and Best Wishes.

Sincerely,
Mohammad Izzuddin bin Yakari

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ABSTRACT

The paper and paperboard industry in Malaysia grew from 1.6% to 35% from 1993 to 2000. The growth highlights the potential of using the 26.2 millions tonnes of oil palm frond (OPF) for pulp and paper production. The research has indicated that the chemical composition of OPF fibers lie between that of hardwoods and that of straws and grasses. OPF fibers can easily be pulped using the chemical process, producing pulp and paper of better properties than most hardwoods pulps. This research also highlights the beating effect in terms of the fiber morphology, paper strength and properties. A P.F.I Mill used to beat the OPF pulps. The beaten pulp was made into fiber network for morphological measurements and the stocks were tested for freeness and drainage time. Handsheets were made from pulp samples taken at different times during the beating process and standard physical test were carried out to give refining curves. The fiber length and diameter decrease with the degree of beating cause of the fragmentation. The soda pulp also gives the effect on drainage time which is increasing with the degree of beating. The content stock freeness (CSF) is decrease with the degree of beating cause of increasing the surface area to absorb water of fine fiber. The high degrees of beating give the strength paper which showed in burst and tensile indices. The study showed that beating effect of soda-AQ pulp produced pulp with different fiber morphology, strength and paper properties.

ABSTRAK

Industri kertas dan papan kertas di Malaysia mengalami pertumbuhan mendadak dari 1.6 % kepada 35 % bermula tahun 1993 sehingga tahun 2000. Pertumbuhan ini menunjukkan potensi penggunaan pelepah kelapa sawit bagi industri pembuatan kertas adalah sebanyak 26.2 juta tan. Kajian menunjukkan komposisi kimia yang terkandung di dalam serat pelepah kelapa sawit menyamai sifat diantara kayu pejal dan spesis rumput dan lalang. Serat pelepah kelapa sawit mudah menghasilkan pulpa melalui proses kimia (alkali) dan sangat berkesan berbanding serat berasaskan kayu pejal. Kajian ini juga menekankan kesan mampatan serat terhadap struktur iaitu panjang serat, kekuatan dan sifat kertas. Alat yang digunakan untuk memampatkan serat adalah P.F.I Mill. Proses pemampatan ini dilakukan untuk ikatan fiber melalui ukuran struktur iaitu panjang serat dan diuji untuk menentukan keupayaan serat menampung air berdasarkan masa air melalui serat. Kertas yang dihasilkan adalah daripada pulpa yang berlainan masa proses pemampatan dan kajian piawai fizikal dilakukan untuk melihat lengkukan berdasarkan graf. Panjang dan ukurlilit serat menurun terhadap masa proses pemampatan disebabkan oleh pemecahan serat semasa pemampatan. Pulpa Soda juga memberi kesan terhadap masa air melalui serat dengan berkadar lansung iaitu meningkat dengan perbezaan masa proses pemampatan. Isipadu air yang ditampung oleh serat menurun terhadap perbezaan masa proses pemampatan, disebabkan oleh peningkatan luas permukaan penyerapan air oleh serat halus. Semakin lama proses pemampatan, akan memberikan kekuatan pada kertas yang dihasilkan melalui nilai ketegangan dan kepecahan yang dicatatkan. Kajian menunjukkan terdapat kesan daripada proses pemampatan pelepah kelapa sawit terhadap struktur serat, kekuatan dan sifat kertas yang dihasilkan.

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LIST OF SYMBOLS

AQ	-	Anthraquinone
CSF	-	Canadian Standard Freeness Method
EFB	-	Empty Fruit Bunch
NaOH	-	Sodium Hydroxide
OPF	-	Oil Palm Frond
OPT	-	Oil Palm Trunk
TAPPI	-	Test & Analysis of Pulp and Paper Institute

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CHAPTER 1

INTRODUCTION

1.1 Background of Study

In Malaysia, the oil palm frond (OPF) was produced 26.2 million tonnes per annum from palm oil industries. Malaysia is the one of the country that exports the palm oil in the world besides Indonesia and Ghana. Recycling is needed to produced something that can be used and avoid the pollution of environment. The production of paper and pulp from palm waste is the best way as a result of environmental issues today. The used paper also can be recycling to produce new paper for packaging, printing and manufacturing.

Figure 1.1: Oil Palm Frond (OPF)

Wood fibers are the main raw material used for the production of pulp and paper. This can be seen from the world wood pulp production amounted to 166.3 million tonnes in 2001 as compared to recovered fiber pulp of 19.8 million tonnes. The recovered fiber is obtained from waste and scrap paper or paperboard, while the other fibers are from vegetable materials such as straw, bamboo, bagasse, kenaf, reeds or grasses, cotton linters, flax hemp, rags, or other textile waste of the total other fiber pulp production, the main producer country in 2001 was China, followed by Australia and India.

In Malaysia, there are 20 paper establishments of these, 10 mills are operating based on recycled papers, while only one mill is using mixed tropical softwoods for its production of pulp and paper. The pulp and paper production from this mill reached 123,000 tonnes in 2001.R&D on pulp and paper has been initiated by FRIM long time ago focusing on the evaluation of the suitability of raw material for pulping and papermaking. One of the R&D findings is the suitability of oil palm frond (OPF) as raw material for pulping. The potential of this finding can be viewed from the facts that there are about 26.2 million tonnes of OPF readily available from the palm oil industry and they are treated as wastes having no value and difficult to dispose. This paper examines the technical feasibility of using OPF in the pulp and paper production and attempt to make an economic analysis on producing pulp and paper from OPF in Malaysia.

1.2 Objectives

1. To utilize Oil Palm Frond (OPF) as alternative source of cellulose based material to produce pulp and paper.
2. To determine the effect of beating on the properties of oil palm frond (OPF) soda-AQ pulp.

1.2 Scopes

The scopes of this study consist of:

1. The effect of beating on fiber morphology
2. The effect of beating on drainage time
3. The effect of beating on content stock freeness (CSF)
4. The effect of beating on paper strength.
5. The optimum condition of beating in paper production.

1.3 Problem statement

A lot of biomass waste not being utilize and converted to high valued product. The Oil Palm Frond (OPF) showed the potential alternatives sources of fresh pulp that replaced to substitute imported fresh pulp. The wood based paper production faced with environmental drawback where sulphur emitted contain through the acidic sulphite & prehydrolysis-kraft pulping process.

CHAPTER 2

LITERATURE REVIEW

2.1 PULP AND PAPER BACKGROUND

Malaysia is net importer of most paper product except for toilet/ tissue paper (Jahaya 1997). In 1996, Malaysia consumed about 325,000 tonnes of newsprint but produced about 5,000 tonnes (Kuusisto 1997). The imported paper and paper product have resulted in a lost in foreign exchage, which can be reduced by utilizing the local lignocellulosic materials in newsprint industry. One of the abundant lignocellulosic residues is the palm oil frond (OPF). Malaysia's 351 palm oil mills produce 26.2 million tones of OPF per annum in the year 2000. Most softwood pulp is produced the soda pulping process (Atchison 1987, Minor 1996).

After the pulping operation, the pulp is often dark in colour. For newsprint production, the pulp should have a brightness of 60-65% (Biermann 1996, Wan Daud *et al*. 1998). Bleaching makes pulp whiter and brighter to the eye. Bleaching is the chemical process applied to the pulp to increase its brightness through lignin removal. Pulp brightness is one of the parameters used in monitoring bleaching progress. An unbleached pulp is colored due to the absorbance of visible light by the presence of residual lignin, highly colored substances. There are more than ten types of bleaching chemicals. Lignin removal is achieved using chlorine, hypochlorite, chlorine dioxide, oxygen or ozone (Reeve 1996). Different types of bleaching chemicals, stages and sequences are used in producing different degree of pulp brightness and will affect the pulp and paper properties.

Beating pulp is one of the most important processes in papermaking. It refers to a mechanical treatment given to pulp fibers during their preparation for papermaking. The principle objective of beating is to optimize fiber properties. The modifications of the pulp fibers are dependent on pulp quality, process conditions, and running conditions of the equipment (Levlin & Jousimaa 1988).

2.1.1 Pulping and pulp characterization

Pulping trials were carried out in a 4 L stationary M.K Digester (NAC Autoclave Co. Ltd., Japan) fitted with a computer-controlled thermocouple. The conditions employed were as follows: liquor-to-material ratio of 8:1, time to maximum cooking temperature of 90 min, time of cook of 120 min, with variations in the white liquor chemical composition (Table 1). After cooking, the pulps were mechanically disintegrated in a three-bladed mixer for 1 min at 2% consistency and screened on a flat-plate screen with 0.15 mm slits (a six-cut slot screen). Rejects and screened yield were determined on oven-dry weight basis. The screened pulps were characterized without being further refined. Kappa number of the screened pulps was determined using TAPPI method T 236. Handsheets were prepared and conditioned at 23 °C and 50% RH for at least 24 hours before testing in accordance with the appropriate TAPPI standard methods.

Table 2.1: Pulping process variables

Pulping type				
Sulfite				
Cook no.	A1	A2	A3	
Na_2SO_3 (%)	100	20	20	
NaOH (%)	100	30	40	
Soda				
Cook no.	B1	B2	B3	B4
NaOH (%)	20	30	40	50

2.1.2 Fiber properties of OPF for pulping and papermaking

Table 2.2: Fiber characteristic of oil palm frond (OPF)

Description	Fiber property	Oil Palm Fronds
Mean fiber length (mm)	Arithmetic	0.59
	Length weighted	1.13
	Weight weighted	1.54
	Coarseness (mg/m)	0.098
Bauer–McNett fractions (%)	R14	0.4
	R28	38.7
	R48	22.9
	R100	16.4
	R200	6.8
	P200	14.8
Fiber dimensions (μm)	Fiber diameter (*D*)	19.6
	Lumen width (*L*)	11.66
	Cell wall thickness (*T*)	3.97
	Rigidity index ($(T/D)^3 \times 10^4$)	83.16

AFL is greatly influenced by short fibers, while the WWFL by very long fibers. The effects of very short and very long components are compensated by using the LWFL. As a comparison, the data from Canadian aspen (*Populus trem.*) are also included. Although the average length is about one-third that of spruce tracheids (Smook, 2002), it is comparable to Canadian aspen (*P. trem.*) of 0.96 mm (Law and Jiang, 2001), Maple of 0.92 (Law et al., 1986), bagasse (0.5–3.75 mm) and wheat straw (0.7–3.1 mm). The bagasse and wheat straw are commercially used for pulp and paper production, as reported by Patel et al. (1987) and Atchinson (1989). Note that the frond fibers are almost twice as long as those of oil palm empty fruit bunch (EFB) fibers (Wan Rosli et al., 1998). However, the coarseness of the oil palm fibers is low (0.097 mg/m), which is slightly halved than that of spruce and significantly lower than of aspen (0.131). The fiber length distribution curve (Fig. 1) indicates a high proportion of short fibers (fines) with further evidence coming from the Bauer–McNett classification which shows a large percentage of short fibers (Table 2.2). One particular morphological attribute of these frond fibers is that they have a much thicker wall when compared with those of wood; consequently, they have a substantially higher rigidity index.

The concept of using rigidity index (or the inverse of collapsibility of fibers) is based on the assumption that fibers act like a thin-wall cylinder whose collapse pressure is proportional to (T/D) (Akamatsu et al., 1987), where T is wall thickness and D is diameter. With thick cell wall (Fig. 2.2), the fibers would not easily collapse during sheet making, hence giving a sheet of higher bulk and lower inter-fiber bonding potential in comparison with the wood counterparts.

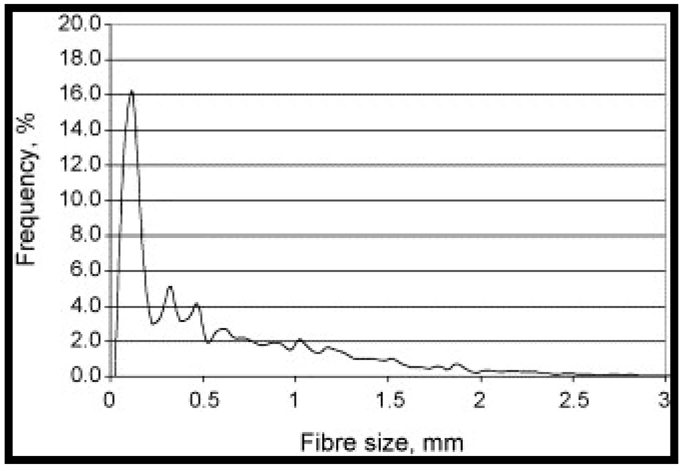

Figure 2.1: A fiber length distribution curve of oil palm frond fibers

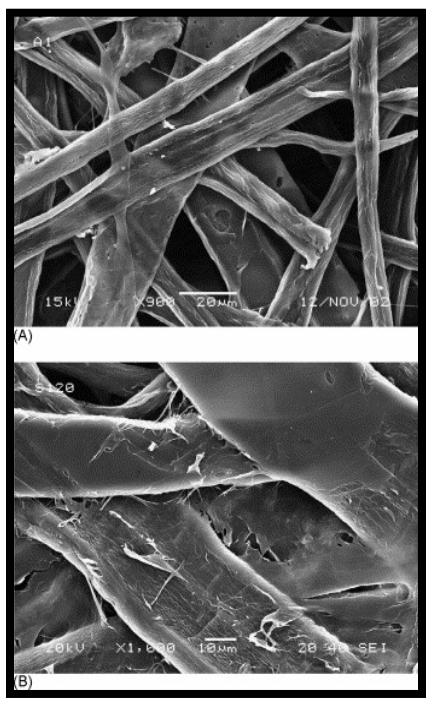

Figure 2.2: SEM of oil palm frond (A) and softwood spruce (B) fibers. Frond fibers have relatively thick cell walls, which do not collapse as readily as the softwood spruce fibers.

2.1.3 Chemical composition of OPF

Chemically, the frond strands are rich in holocellulose (83.5%) and also high in α-cellulose (49.8%) as illustrated in 2, both of which are important parameters in determining the suitability of a raw material for papermaking (Ona et al., 2000). As a comparison, the data from Canadian aspen (*P. trem.*) is also included. The lignin content (20.5%) is lower than normally found in common hardwood, for example aspen of 18.1% (Law and Jiang, 2001) and eucalyptus of 22% (Alcaide et al., 1990), which is not surprising since oil palm trees are non-woody and the requirement for structural support is lower compared to that of trees. The functional significance of lignin has long been associated with mechanical support for plant organs that enables increased growth in height (Boudet, 2000 and Douglas, 1996), its lacking will no longer allow plants to be upright (Zhong et al., 1997). This is an added advantage in that they will be much easier to be chemically pulped. The frond strands are comparatively less resinous than those of wood, as evidenced by the lower levels of extractives soluble in alcohol–benzene.

It should also be noted that the frond strands, like other non-wood fibers, contain comparatively high ash content. This characteristic might contribute to an abnormal mechanical wear of processing equipments. The potential build up of silica in the black liquor recovery system might also be a concern in pulping of this material. The monomer composition of polysaccharides shows almost only glucose and xylose, with the other monosaccharides representing less than 6%, which is in broad similarity with that of hardwoods (Timmell, 1967 and Wallis et al., 1996).